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(54) Multi-passband filter

(57) The invention provides a multi-passband filter comprising a dielectric member (1), a plurality of resonant lines (12a-12c, 13, 14a-14d, 15a-15c) associated with said dielectric member (1) and each of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) each being coupled to an adjacent one of resonant lines, which is characterized in that at least one pair of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) are interdigitally coupled to each other with respective open-circuited ends and short-circuited ends of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) being located at opposite portions of said dielectric member, thereby providing a band-elimination filter.

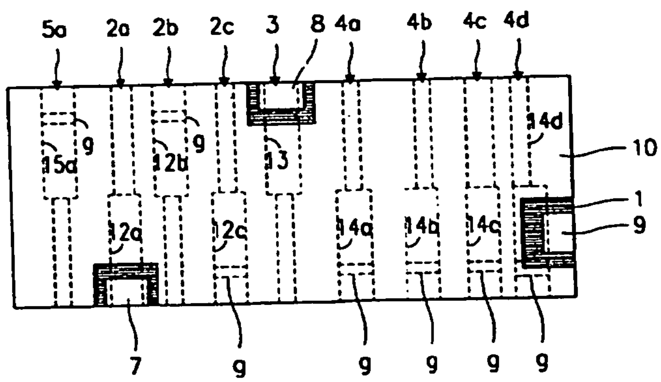

FIG.1B

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a multi-passband filter. More particularly, the invention relates to a multi-passband filter comprising a dielectric member, a plurality of resonant lines provided within/on said dielectric member, and each of the resonant lines being coupled to the adjacent resonant lines. The multi-passband filter is for use in mobile communication apparatus.

2. Description of the Related Art

An example of a conventional antenna-duplexer unit formed by a plurality of filters in a single dielectric block is shown in Fig. 14. Fig. 14A is a front view of the dielectric filters for use in the antenna-duplexer unit, and Fig. 14B is a longitudinal sectional view of the dielectric filters which are vertically placed. In Figs. 14A and 14B, a dielectric block 1 has ground conductors 10 on the peripheral surfaces other than the front surface of the dielectric block 1. A plurality of resonant-line holes 31a through 31i are provided in the dielectric block 1 in which resonant lines 32a through 32i are formed, respectively. Rectangular shaped electrodes, continuously extending from the respective resonant lines 32a through 32i, are formed on the open front surface of the dielectric block 1. Moreover, input/output-coupling electrodes 33a, 33b and 33c are inserted between the resonant-line holes 31a and 31b, between the holes 31d and 31e, and between the holes 31h and 31i, respectively, thereby capacitively coupling the adjacent rectangular electrodes. In this manner, the following types of filters are respectively formed: a band-pass filter consisting of three stages of resonators in a region indicated by F2; a band-pass filter formed of four stages of resonators in a region indicated by F3; and band-elimination filters (trap circuits), each formed of a one-stage resonator, in regions indicated by F1 and F4, respectively. Further, the input/output-coupling electrodes 33a, 33b and 33c are used as a transmitting (Tx) terminal, an antenna (ANT) terminal, and a receiving (Rx) terminal, respectively. In this manner, an antenna-duplexer unit is formed.

The above known type of antenna-duplexer unit, such as the one shown in Fig. 14, however presents the following problems. Either of the transmitting filter or the receiving filter in this unit is adapted to reject the passband of the other filter due to its respective band-pass filter characteristics. This requires a large number of resonator stages, which would otherwise fail to obtain a sufficient attenuation in the attenuation band, thereby inevitably enlarging the unit. One possible measure to overcome the above drawback may be to use a band-elimination filter as the transmitting filter. If, however, a multi-passband filter is formed of a single dielectric block, a transmission-line conductor is required for coupling adjacent resonators with a phase difference of $\pi/2$ (rad). As the transmission line, a microstripline on a dielectric should be used, and the electric length of the microstripline is accordingly longer than the length of the resonator, thereby increasing the dimensions of the space required for an array of the resonators.

Moreover, if the foregoing problem encountered by the known antenna-duplexer unit is solved simply by using a band-elimination filter as the transmitting filter, the impedance in the passband of the receiving filter, i.e., in the elimination band of the transmitting filter, as viewed from the receiving filter to the transmitting filter, becomes approximately zero. Thus, a receiving signal input from the antenna disadvantageously flows into the transmitting filter rather than the receiving filter. In order to avoid this inconvenience, a phase shifter having an electric length of $\pi/2$ may be provided between the transmitting filter and the antenna terminal so that the impedance viewed from the receiving filter in the stop band of the transmitting filter becomes approximately infinite. However, this requires a large number of parts, which further increases the cost.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a multi-passband filter formed of a plurality of filters including a band-elimination filter without increasing the size of the band-elimination filter.

It is another object of the present invention to provide a multi-passband filter formed of a plurality of filters including a band-elimination filter, free from the above-described problems, in which the band-elimination filter in the elimination band is substantially an open circuit as viewed from the other filter without requiring a phase shifter when the band-elimination filter and the other filter are combined so as to be able to input or output signals through a common input/output terminal.

The invention provides a multi-passband filter of the above mentioned kind, which is characterized in that at least one pair of said resonant lines are interdigitally coupled to each other with respective open-circuited ends and short-circuited ends of said resonant lines being located at opposite portions of said dielectric member, thereby providing a band-elimination filter.

In the above filter, the interdigitally-coupled portion serves as a band-elimination filter (trap circuit). More specifically, in the above structure, the self capacitance between a ground electrode and each of the above-described interdigitally-coupled resonant lines per unit length is indicated by C_{11}, while the inter-line mutual capacitance between the two resonant lines per unit length is represented by C_{12}. Then, the even-mode characteristic impedance Ze, the odd-mode characteristic impedance Zo, and the coupling-characteristic impedance Zk are respectively expressed by the follow-

ing equations:

$$Ze = \sqrt{(\varepsilon r)}/(vc \cdot C_{11})$$

$$Zo = \sqrt{(\varepsilon r)}/\{vc(C_{11} + 2C_{12})\}$$

$$Zk = 2Ze \cdot Zo/(Ze - Zo) = \sqrt{(\varepsilon r)}/(vc \cdot C_{12})$$

wherein εr indicates the relative dielectric constant of the dielectric member used in this unit, and vc designates the velocity of light. The above-described interdigitally-coupled portion of the two resonant lines can be represented by the equivalent circuit in which a series circuit formed of the coupling-characteristic impedance Zk between the two resonant lines and the even-mode characteristic impedance Ze of one resonant line is connected in parallel to the even-mode characteristic impedance Ze of the other resonant line, thereby forming a trap circuit.

If the length of each resonant line is designated by L, the electric length θ can be expressed by the following equation:

$$\theta = \omega\sqrt{(\varepsilon r)} \cdot L/vc$$

where θ is equal to $\pi/2$, and ω equals $2\pi f$, and thus, the trap frequency f_T of the foregoing trap circuit can be expressed by the following equation:

$$f_T = vc/\{4\sqrt{(\varepsilon r)} \cdot L\}$$

In this manner, a plurality of pairs of resonant lines are provided in such a manner that the open end and the short-circuited end of one line are located in positions opposite to those of the other line. Thus, the band-elimination filter characteristics in which signals are attenuated in a predetermined bandwidth can be obtained without requiring a transmission line, which is conventionally needed for coupling the adjacent resonators with an electric length of $\pi/2$. Accordingly, only a limited space is required for disposing the band-elimination filter in the unit, thereby downsizing the overall unit.

In the above multi-passband filter, at least one pair of said resonant lines may be comb-line coupled to each other with respective open-circuited ends and short-circuited ends of said resonant lines being located in the same portions of said dielectric member, thereby providing a band-pass filter.

With this configuration, it is possible to implement an antenna-duplexer unit having a band-elimination filter as a transmitting filter and a band-pass filter as a receiving filter.

In the above multi-passband filter, said dielectric member may be a dielectric block, and said plurality of resonant lines may be provided within said dielectric block.

In the above multi-passband filter, said dielectric member may be a dielectric plate, and said plurality of resonant lines may be provided on said dielectric plate.

In the above multi-passband filter, a non-conductive portion is preferably provided at a part of at least one of said resonant lines to form said open-circuited end.

With this arrangement, the position and width of each of the gaps are determined or adjusted in the adjusting process step to easily achieve the desired characteristics while maintaining the overall configuration and dimensions of the dielectric member, and the resonant lines. When the open ends formed by the non-conductive portions are positioned within the dielectric block, electromagnetic leakage to the exterior from the unit and electromagnetic coupling with an external circuit are reduced, thereby realizing stable characteristics.

When said dielectric member is a dielectric block and said plurality of resonant lines are provided within said dielectric block, one end of each of said resonant lines on a surface of said dielectric block may be opened, and a coupling electrode for coupling the adjacent resonant lines may be provided at said one end of each of said resonant lines.

With this arrangement, the configuration and pattern of the resonant lines within the dielectric block can be simplified.

In the above multi-passband filter, an input/output-coupling electrode may be provided to couple to one of said resonant lines providing said band-elimination filter with a phase shift of an electric angle of $\pi/2$, wherein said one of said resonant lines providing said band-elimination filter is the first or last one thereof.

With this configuration, the impedance in the attenuation band of the band-elimination filter as viewed from the other filter can be shifted from approximately zero to substantially infinite, in other words, the band-elimination filter can be substantially an open circuit as viewed from the other filter. As a consequence, when the foregoing filter unit is employed as an antenna-duplexer unit in which the band-elimination filter is used as transmitting filter, a receiving signal can be reliably transmitted to the receiving filter, which would otherwise flow into the transmitting filter and attenuated.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A through 1D	schematically illustrate a multi-passband filter according to a first embodiment of the present invention;
Fig. 2	is a diagram illustrating the equivalent circuit of the filter shown in Fig. 1;
Fig. 3	illustrates the band-pass characteristics of the filter shown in Fig. 1;
Fig. 4	is a block diagram illustrating the filter shown in Fig. 1;
Figs. 5A through 5D	schematically illustrate a multi-

passband filter according to a second embodiment of the present invention;

Fig. 6 is a diagram illustrating the equivalent circuit of the filter shown in Fig. 5;

Figs. 7A through 7D schematically illustrate a multi-passband filter according to a third embodiment of the present invention;

Fig. 8 is a diagram illustrating the equivalent circuit of the filter shown in Fig. 7;

Figs. 9A through 9D schematically illustrate a multi-passband filter according to a fourth embodiment of the present invention;

Figs. 10A through 10D schematically illustrate a multi-passband filter according to a fifth embodiment of the present invention;

Fig. 11 is a plan view of a multi-passband filter according to a sixth embodiment of the present invention;

Figs. 12A through 12D schematically illustrate a multi-passband filter according to a seventh embodiment of the present invention;

Figs. 13A through 13D schematically illustrate a multi-passband filter according to an eighth embodiment of the present invention; and

Figs. 14A and 14B schematically illustrate a conventional multi-passband filter.

Other features and advantages of the invention will become more apparent from the following description of embodiments thereof, which refers to the accompanying drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 schematically illustrates a multi-passband filter: Fig. 1A illustrates the top surface of the filter; Fig. 1B illustrates the front surface of the filter; Fig. 1C illustrates the bottom surface of the filter; and Fig. 1D illustrates the right lateral surface of the filter. This filter is formed of a rectangular prism-shaped dielectric block 1 provided with various holes and electrodes. More specifically, the filter has resonant-line holes 2a, 2b and 2c, and 5a, 5b and 5c for the transmitting filter and resonant-line holes 4a, 4b, 4c and 4d for the receiving filter, both of which are used when the filter unit is employed as an antenna-duplexer. The filter also includes an input/output-coupling-line hole 3. Fig. 1B shows that the resonant-line holes are each formed as a stepped hole having different internal diameters between the upper and lower halves in which an electrode is disposed to form a resonant line. It should be noted that the holes 5b and 5c are not shown in Fig. 1B for the purpose of clarity. Resonant lines 12a, 12b and 12c are formed in the resonant-line holes 2a, 2b and 2c, respectively; a resonant line 15a is disposed in the resonant-line holes 5a; and resonant lines 14a, 14b, 14c and 14d are provided in the resonant-line holes 4a, 4b, 4c and 4d, respectively. Further, an input/output-coupling resonant line (input/output-coupling electrode) 13 is formed in the input/output-coupling-line hole 3. Moreover, each of the resonant lines other than the resonant line 12a and the input/output-coupling resonant line 13 is provided with a non-conductive portion indicated by g in the vicinity of the outer end of the enlarged portion of the stepped hole, the portion g defining an open end. In Fig. 1A, there are shown ground holes 6a, 6b and 6c, which are formed as straight holes having a constant internal diameter, an electrode being provided within the entire length of each of the holes 6a, 6b and 6c. Formed on the outer surfaces of the dielectric block 1 are input/output terminals 7 and 8, continuously extending from the resonant lines 12a and 13, respectively, and an input/output terminal 9, which is capacitively coupled with the resonant line 14d. Additionally, a ground electrode 10 is formed over substantially all of the surfaces (six surfaces) of the block 1 apart from the input/output terminals 7, 8 and 9.

The operation of the multi-passband filter constructed as described above is as follows. The resonant lines 14a, 14b, 14c and 14d respectively formed in the holes 4a, 4b, 4c and 4d are comb-line-coupled to each other, while the resonant line 14a and the input/output-coupling resonant line 13 are interdigitally-coupled. With this arrangement, a band-pass filter is formed between the input/output terminals 8 and 9. Meanwhile, the resonant lines 12a, 12b and 12c respectively provided in the holes 2a, 2b and 2c are interdigitally-coupled to each other, and the resonant line 12c and the input/output-coupling resonant line 13 are also interdigitally-coupled. Moreover, the resonant lines formed in the respective holes 5a, 5b and 5c are interdigitally-coupled to the resonant lines 12a, 12b and 12c, respectively. In other words, interdigital-coupling is established between the two resonant lines formed in the respective holes 2a and 5a, between the resonant lines provided in the respective holes 2b and 5b, and between the resonant lines formed in the respective holes 2c and 5c. Accordingly, the input/output terminals 7 and 8 are coupled to each other with a phase shift of $\pi/2$ between each of the resonant lines 12a, 12b and 12c so as to form a band-elimination filter having three trap circuits. The ground hole 6a interrupts the coupling force between the resonant-line holes 5a and 5b by its shielding action, while the ground hole 6b intercepts the coupling force between the resonant-line holes 5b and 5c by its shielding action. Similarly, the ground hole 6c

interrupts the coupling force between the resonant-line holes 4a and 5c by its shielding action.

As noted above, in Fig. 1, the resonant line 12c, which serves as the last resonant line consituting the transmitting filter, is interdigitally-coupled to the input/output-coupling resonant line (input/output-coupling electrode) 13 with a phase shift of $\pi/2$. This interdigital coupling can be represented by the block diagram of Fig. 4. With this configuration, in the attenuation band of the transmitting filter, the impedance of the transmitting filter viewed from the input/output-coupling resonant line 13 to the transmitting filter is substantially infinite, and a receiving signal from the antenna is thus input into the receiving filter rather than the transmitting filter.

Fig. 2 is a diagram illustrating the equivalent circuit of the multi-passband filter shown in Fig. 1. In this diagram, Ze and θ respectively represent the even-mode characteristic impedance and the electric angle of each resonant line shown in Fig. 1. Zk and θ indicated on the horizontal straight line for connecting the transmitting filter and the receiving filter shown in Fig. 2 respectively designate the coupling characteristic impedance and the electric angle between the resonant lines 12a, 12b and 12c, between the resonant lines 14a, 14b, 14c and 14d, between the input/output-coupling resonant line 13 and the resonant line 14a, and between the input/output-coupling resonant line 13 and the resonant line 12c. Further, Zk and θ on the lines branched from the above-described straight lines respectively indicate the coupling characteristic impedance and the electric angle between the resonant lines formed in the slots 5a, 5b and 5c and the resonant lines 12a, 12b and 12c, respectively.

Fig. 3 illustrates the band-pass characteristics of the multi-passband filter shown in Figs. 1 and 2. Fig. 3 reveals that the band-pass characteristics of the transmitting filter (Tx filter) result from synthesizing the band-pass filter characteristics exhibited by the resonant lines 12a, 12b and 12c and the input/output-coupling resonant line 13 with the band-elimination filter characteristics of the foregoing three trap circuits, while the band-pass characteristics of the receiving filter (Rx filter) originate from the band-pass filter characteristics exhibited by the resonant lines 14a, 14b, 14c and 14d shown in Fig. 1. The attenuation band of the transmitting filter and the pass band of the receiving filter coincide with the receiving band, while the pass band of the transmitting filter and the attenuation band of the receiving filter match the transmitting band. As a consequence, the foregoing multi-passband filter can be used as an antenna-duplexer.

Fig. 5 schematically illustrates a multi-passband filter according to a second embodiment of the present invention. Fig. 5A illustrates the top surface of the filter; Fig. 5B illustrates the front surface of the filter; Fig. 5C illustrates the bottom surface of the filter; and Fig. 5D illustrates the right lateral surface of the filter. This filter, like the counterpart shown in Fig. 1, is formed of a rectangular prism-shaped dielectric block 1 provided with various holes and electrodes. The filter of the second embodiment, however, differs from the filter of the first embodiment in the following respects. First, the resonant-line holes 4d and 2a, and the input/output-coupling-line hole 3 are formed as straight holes with a constant diameter, and an input/output terminal 9 is directly connected to one end of the resonant-line hole 4d. Further, a ground hole 6d is provided in the vicinity of the resonant-line hole 4d to weaken the coupling force between the resonant line 14c and the resonant line 14d, which serves as the last resonant line of the receiving filter, thereby shortening the distance between the resonant-line holes 4c and 4d. Additionally, the position and size of the ground hole 6d can be changed to adjust the external Q (Qe).

Fig. 6 is a diagram illustrating the equivalent circuit of the multi-passband filter shown in Fig. 5. Fig. 6 reveals that the second embodiment in which an input/output terminal is directly connected to a resonant-line hole of the receiving filter exhibits characteristics similar to those obtained by the first embodiment.

Figs. 7 and 8 illustrate the configuration of a multi-passband filter according to a third embodiment of the present invention. In this filter, the number of resonant lines is fewer than the number of resonators in the multi-passband filter of the second embodiment shown in Figs. 5 and 6. More specifically, Fig. 7A illustrates the top surface of the above type of filter; Fig. 7B illustrates the front surface of the filter; Fig. 7C illustrates the bottom surface of the filter; and Fig. 7D illustrates the right lateral surface of the filter. The filter is formed of a rectangular prism-shaped dielectric block 1. Resonant-line holes 5a, 2a, 4a, 4b, and 4c and an input/output-coupling line hole 3 are provided in the dielectric block 1 within which resonant lines 15a, 12a, 14a, 14b, 14c, and an input/output-coupling resonant line 13 are respectively formed. Input/output terminals 7 and 9 are respectively disposed at the ends of the resonant-line holes 2a and 4c, while an input/output terminal 8 is provided at an end of the input/output-coupling line hole 3.

Fig. 8 is a diagram illustrating the equivalent circuit of the filter shown in Fig. 7. With this configuration, it is possible to implement an antenna-duplexer formed by integrating a transmitting filter having band-stop characteristics with one trap circuit and a receiving filter exhibiting band-pass characteristics including two comb-line-coupled resonators.

Fig. 9 schematically illustrates a multi-passband filter according to a fourth embodiment of the present invention. In this filter, the number of resonators is reduced by one from the resonators of the transmitting filter shown in Fig. 5. The other configurations are similar to those of the filter shown in Fig. 5. Accordingly, the input/output terminal 7 provided at the end of the resonant line 12a is shown on the top surface of the filter, as illustrated in Fig. 9A, and all the input/output terminals

7, 8 and 9 are thus in the same plane.

Fig. 10 schematically illustrates a multi-passband filter according to a fifth embodiment of the present invention. This filter differs from the counterparts of the foregoing embodiments in that one end of each resonant-line hole is open-circuited and has an electrode pattern, preferably rectangular, disposed thereat, and that all the resonant-line holes are formed as straight holes having a constant diameter. With this arrangement, the formation of a non-conductive portion within each resonant-line hole is unnecessary, and the resonant-line holes can be formed straight with a constant diameter, thereby easily fabricating the filter. The equivalent circuit of the multi-passband filter of the fifth embodiment is similar to the counterpart of the second embodiment shown in Fig. 6.

According to the foregoing embodiments, the filter is formed by using a single dielectric block. In contrast, in the below-described embodiments, a dielectric plate is used in place of the dielectric block.

Fig. 11 is a plan view of a multi-passband filter according to a sixth embodiment of the present invention. In Fig. 11, the filter employs a dielectric plate 21 on which resonant lines 12a, 12b, 12c, 14a, 14b, 14c, 14d, 13, 15a, 15b, and 15c are formed. The resonant lines 14a, 14b and 14c function as a λ/2 resonator with both ends open-circuited, and are comb-line-coupled to each other. Further, the resonant lines 13 and 14a are interdigitally-coupled to each other, and the resonant lines 14c and 14d are also interdigitally-coupled to each other. As a consequence, a band-pass filter can be formed between the ANT terminal and the Rx terminal. Meanwhile, the resonant lines 12a, 12b, 12c and 13 are interdigitally-coupled to each other, and interdigital-coupling is also established between the resonant lines 12a and 15a, between the lines 12b and 15b, and between the lines 12c and 15c, thereby forming three trap circuits. Accordingly, the band-elimination filter characteristics formed by synthesizing the band-pass filter characteristics exhibited by the resonant lines 12a, 12b, 12c and 13 with the band-elimination filter characteristics of the above three trap circuits can be obtained between the Tx terminal and the ANT terminal. As a result, the equivalent circuit of the filter of this embodiment is similar to that of the counterpart of the second embodiment shown in Fig. 5.

Fig. 12 schematically illustrates a multi-passband filter according to a seventh embodiment of the present invention. Fig. 12A illustrates the rear surface of the filter; Fig. 12B illustrates the top surface of the filter; Fig. 12C illustrates the front surface of the filter; and Fig. 12D illustrates the bottom surface of the filter. Formed on the dielectric plate 21 are resonant lines 15a, 12a, 13, 14a, 14b and 14c. Among the above lines, a non-conductive portion is provided at a predetermined portion of each of the resonant lines 15a, 14a and 14b and provides an open-circuited end. Moreover, input/output terminals 8 and 9, continuously extending from the respective resonant lines 13 and 14c, are formed from the rear surface to the bottom surface of the dielectric plate 21, while an input/output terminal 7, continuously extending from the resonant line 12a, is provided from the front surface to the bottom surface of the dielectric plate 21. Further, a ground electrode 10 is formed in a region other than the top surface of the dielectric plate 21 and the above-described input/output terminals 7, 8 and 9.

The filter shown in Fig. 12 is a modification made to the filter of the third embodiment shown in Fig. 7 in such a manner that the dielectric plate 21 is used in place of the dielectric block 1. The operation and characteristics of this modification are similar to those of the third embodiment.

Fig. 13 schematically illustrates a multi-passband filter according to an eighth embodiment of the present invention. This filter is a triplate-type modification of the filter shown in Fig. 12. More specifically, the filter of this embodiment has two dielectric plates 21a and 21b. Various resonant lines similar to those of the filter shown in Fig. 12 are formed on one dielectric plate 21a, while resonant lines configured mirror-symmetrically to those shown in Fig. 12 are disposed on the other dielectric plate 21b. Then, the surfaces of the two dielectric plates 21a and 21b on which the resonant lines are formed are laminated. With this arrangement, since the respective resonant lines are surrounded by the ground electrode 10, electromagnetic leakage to the exterior from the filter and electromagnetic coupling with an external circuit can be inhibited, thereby obtaining a multi-passband filter exhibiting stable characteristics.

As an application of the foregoing embodiments, an antenna-duplexer has been discussed. The present invention is not limited, however, to filters of the types which have a transmitting filter and a receiving filter so as to be usable with a transmitter and a receiver. The invention may more generally be applicable to filters which filter a plurality of input signals to obtain one output, or filters which filter one input signal to obtain a plurality of outputs.

Claims

1. A multi-passband filter, comprising:

   a dielectric member (1),

   a plurality of resonant lines (12a-12c, 13, 14a-14d, 15a-15c) associated with said dielectric member (1), and each of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) each being coupled to an adjacent one of said resonant lines,
   characterized in that

   at least one pair of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) are interdigitally

coupled to each other with respective open-circuited ends and short-circuited ends of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) being located at opposite portions of said dielectric member, thereby providing a band-elimination filter.

2. A multi-passband filter according to claim 1, characterized in that

at least one pair of said resonant lines (14a-14d) are comb-line coupled to each other with respective open-circuited ends and short-circuited ends of said resonant lines (14a-14d) being located in the same portions of said dielectric member, thereby providing a band-pass filter.

3. A multi-passband filter according to claim 1 or 2, characterized in that

said dielectric member (1) is a dielectric block (1), and said plurality of resonant lines (12a-12c, 13, 14a-14d, 15a-15c) are provided within said dielectric block.

4. A multi-passband filter according to claim 1 or 2, characterized in that

said dielectric member (21) is a dielectric plate (21), and said plurality of resonant lines (12a-12c, 13, 14a-14d, 15a-15c) are provided on said dielectric plate (21).

5. A multi-passband filter according to one of claims 1 to 4, characterized in that

said open-circuited end is defined by a non-conductive portion in at least one of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c).

6. A multi-passband filter according to claim 3, characterized in that

one end of each of said resonant lines (12a-12c, 13, 14a-14d, 15a-15c) at a surface of said dielectric block (10) defines said open-circuited end, and

a coupling electrode for coupling the adjacent resonant lines is provided at said open-circuited end of each of said resonant lines.

7. A multi-passband filter according to one of claims 1 to 6, characterized in that

an input/output-coupling electrode (13) is provided which couples to a first one or a last one of said resonant lines providing said band-elimination filter (12a-12c) with a phase shift of an electric angle of $\pi/2$.

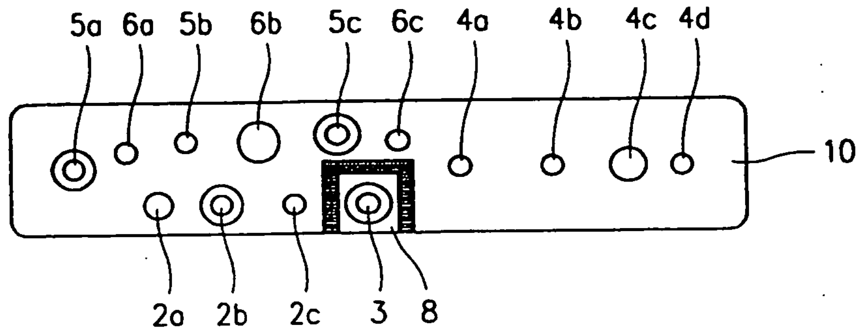

FIG. 1A

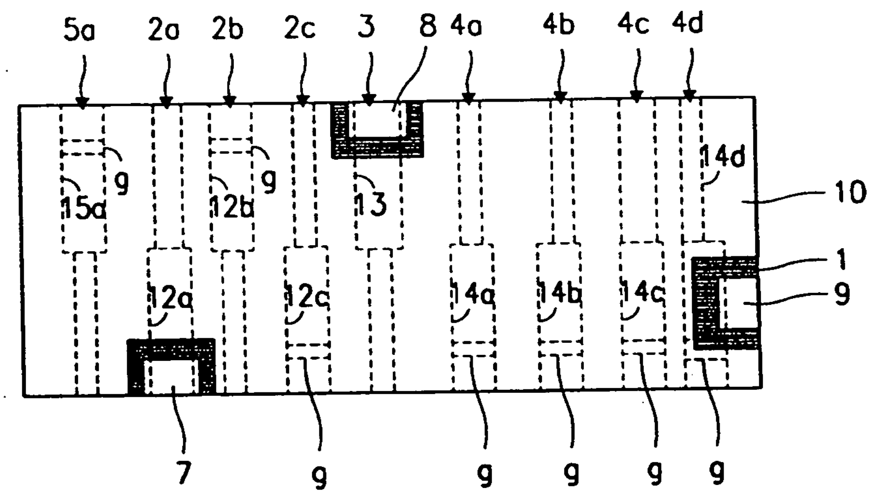

FIG. 1B

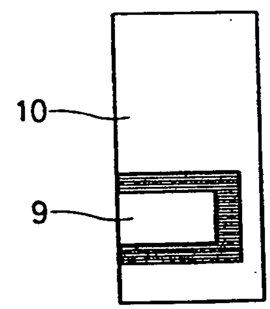

FIG. 1D

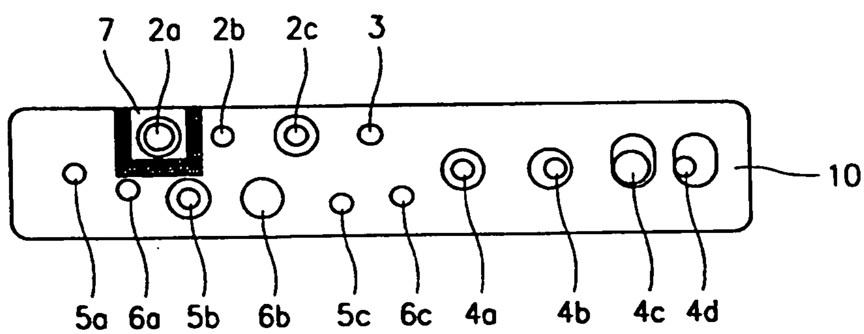

FIG. 1C

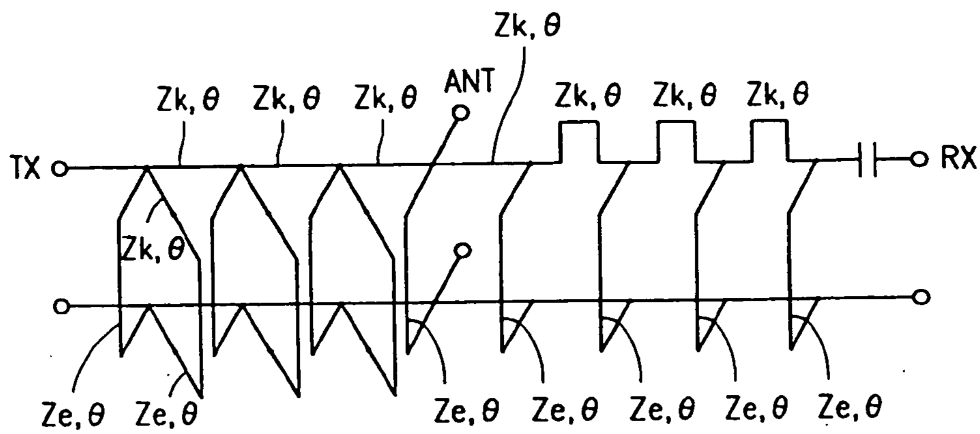

FIG.2

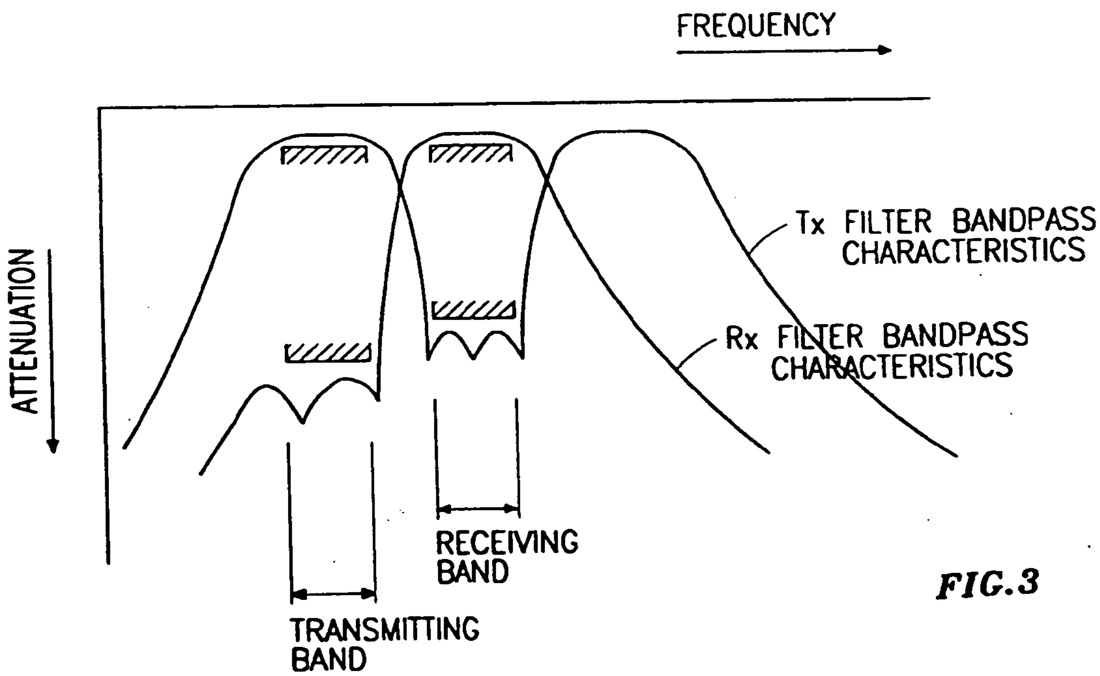

FIG.3

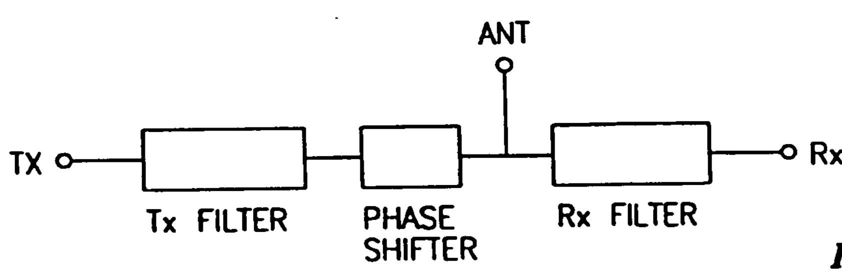

FIG.4

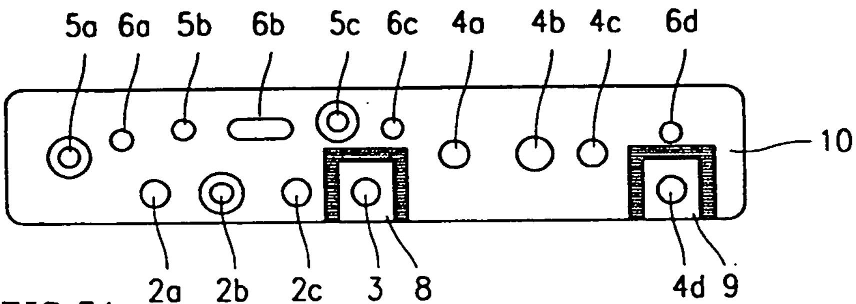

FIG.5A

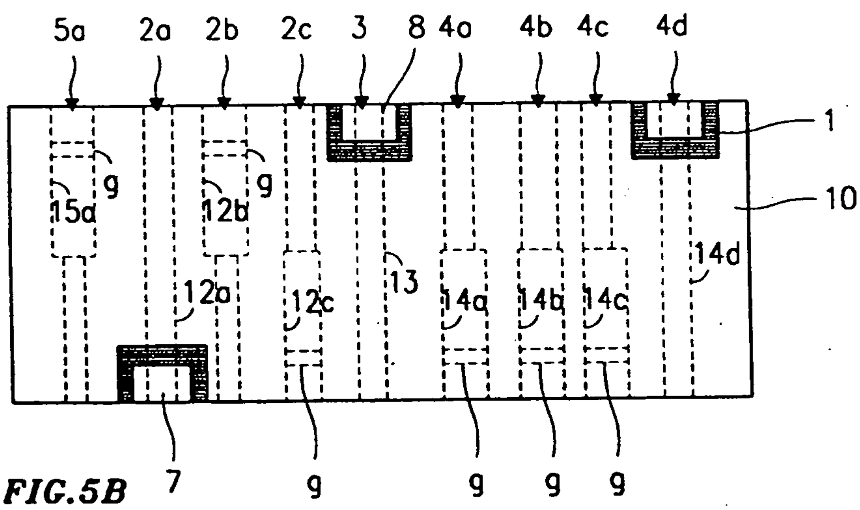

FIG.5B

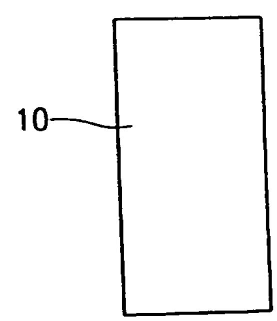

FIG.5D

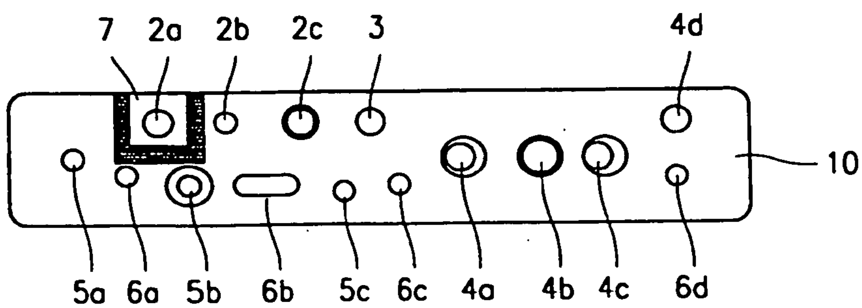

FIG.5C

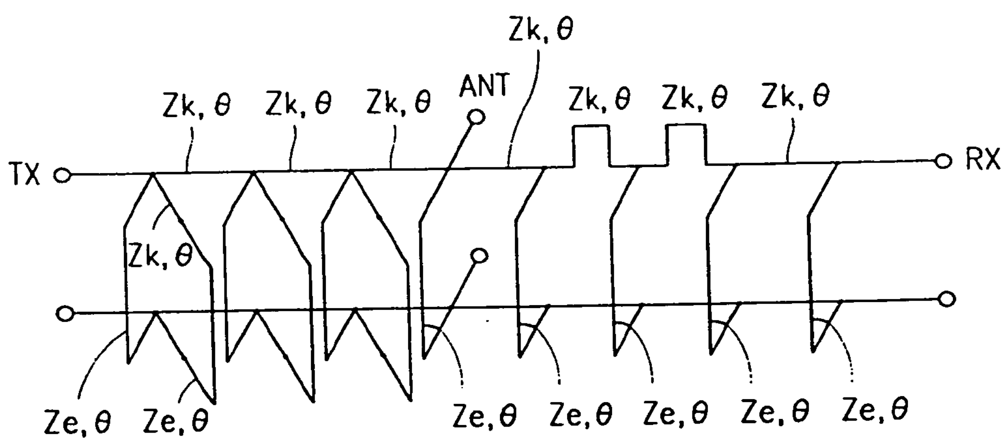
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FIG.6

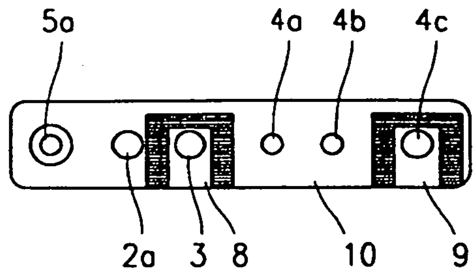

FIG.7A

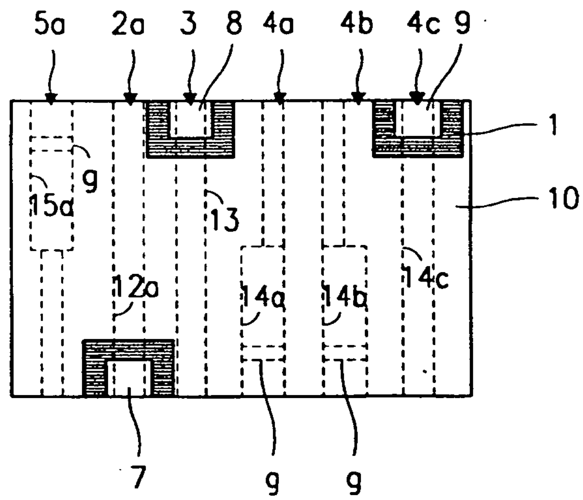

FIG.7B

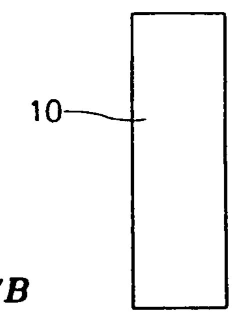

FIG.7D

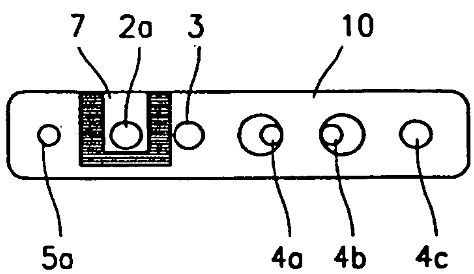

FIG.7C

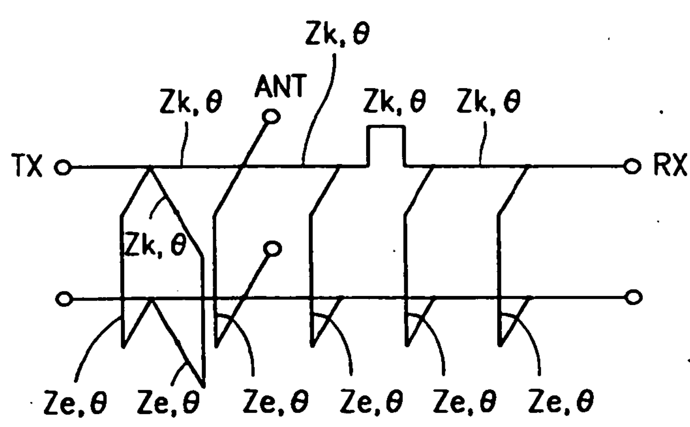

FIG.8

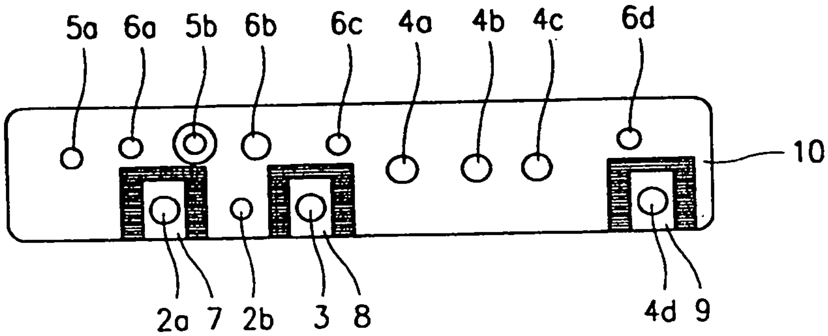

FIG.9A

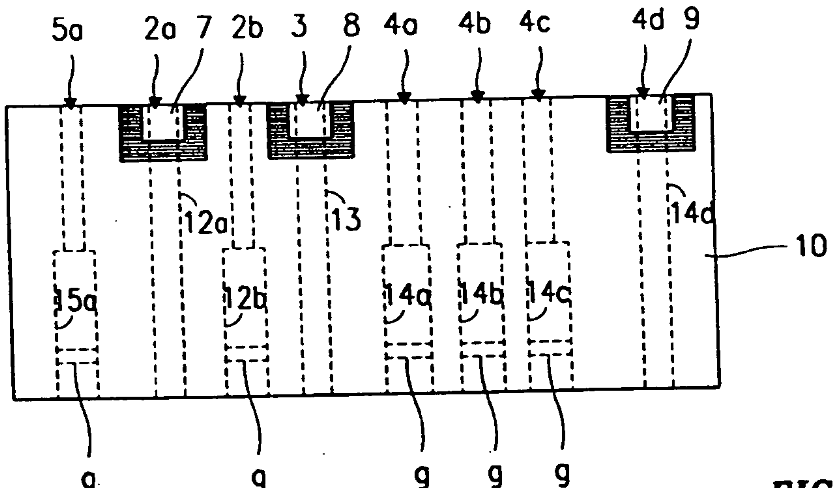

FIG.9B

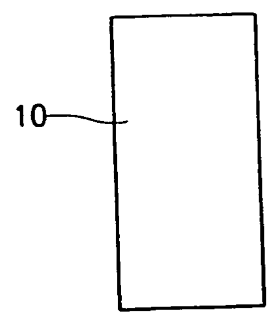

FIG.9D

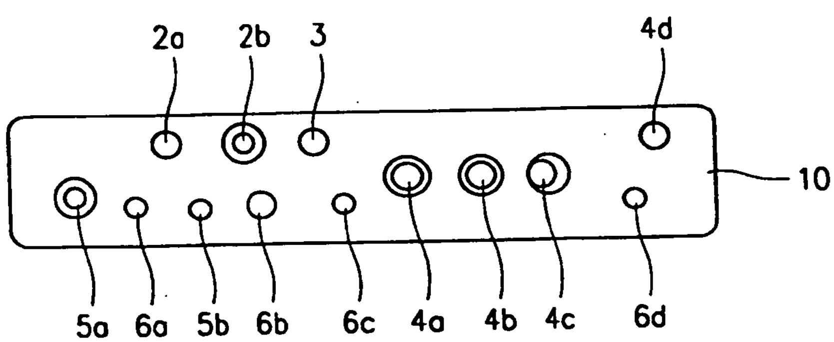

FIG.9C

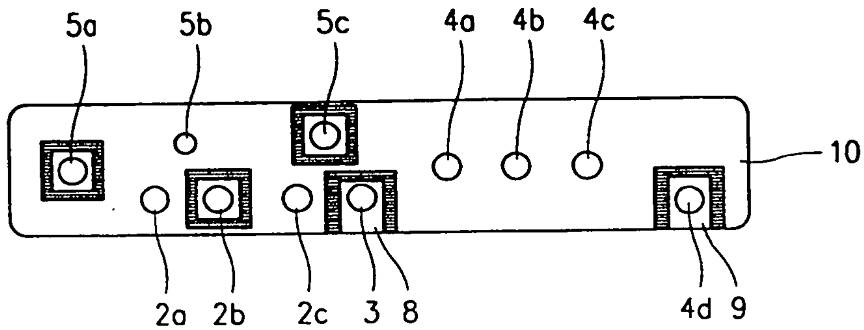

FIG. 10A

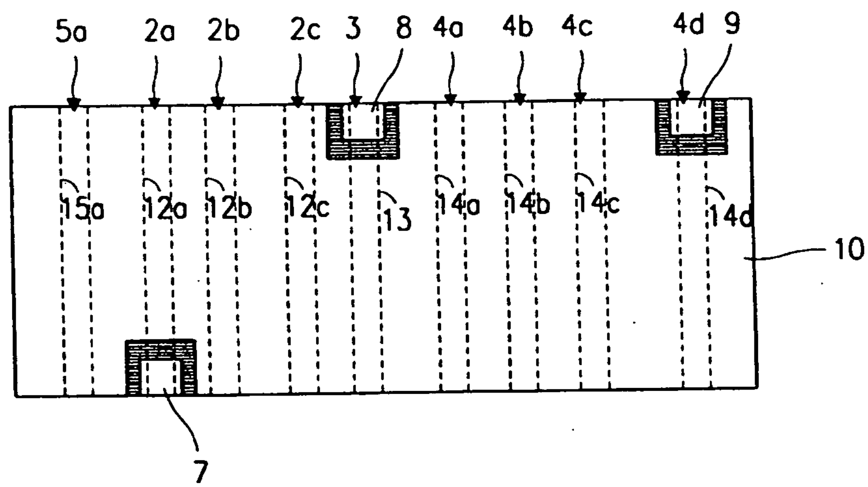

FIG. 10B

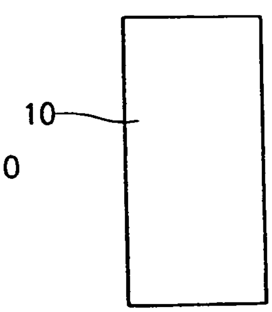

FIG. 10D

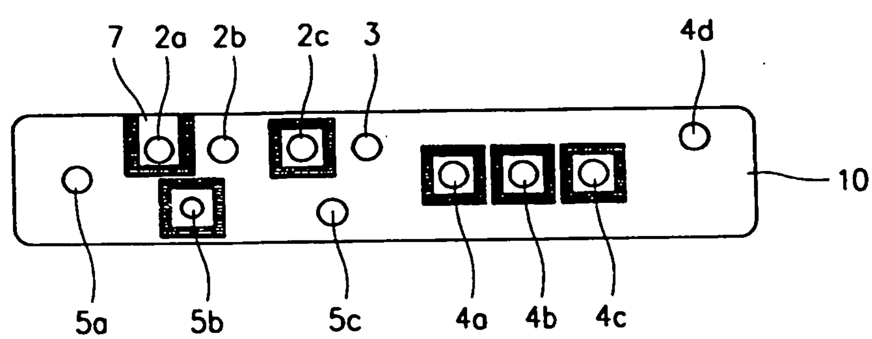

FIG. 10C

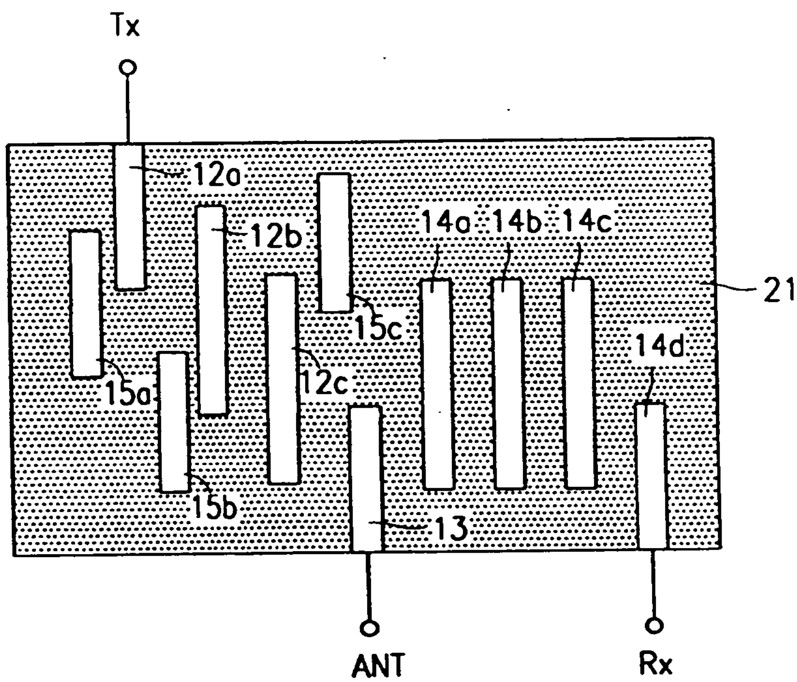

FIG.11

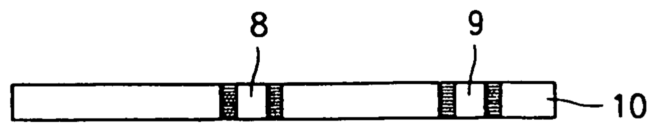

FIG. 12A

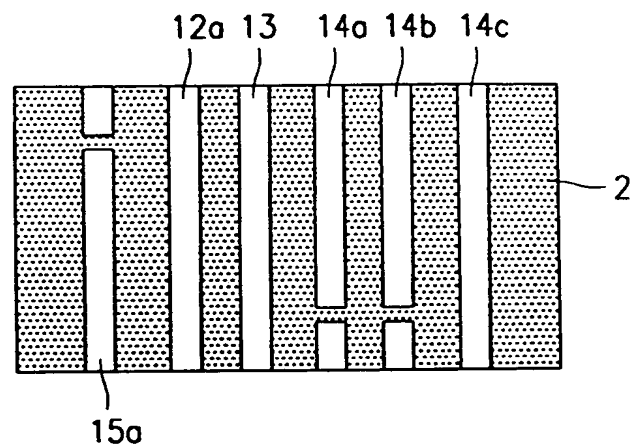

FIG. 12B

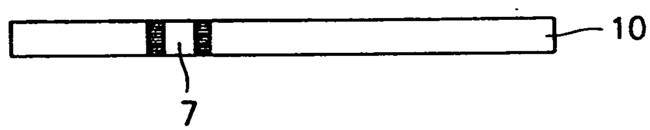

FIG. 12C

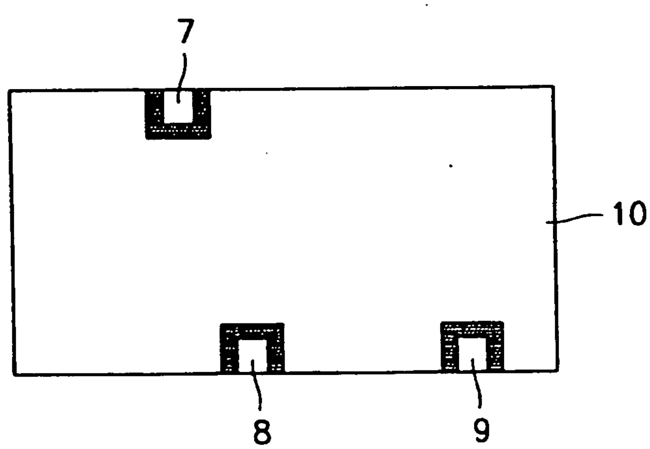

FIG. 12D

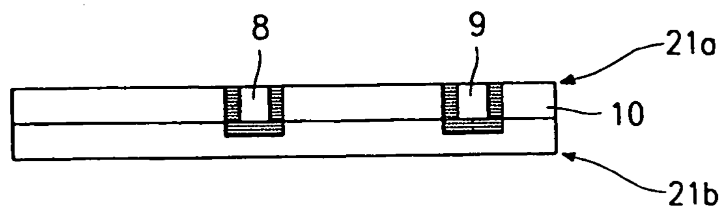

FIG.13A

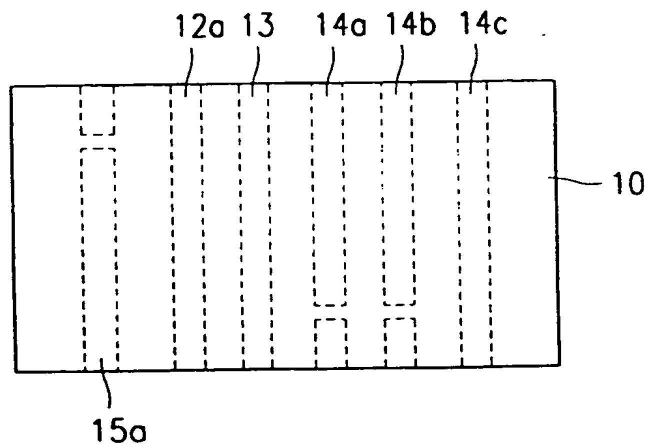

FIG.13B

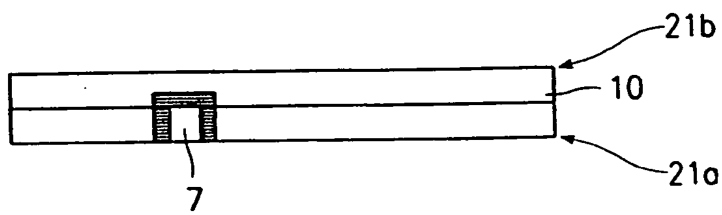

FIG.13C

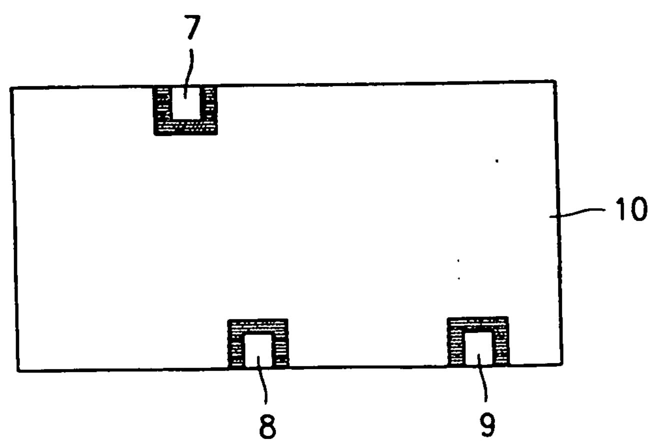

FIG.13D

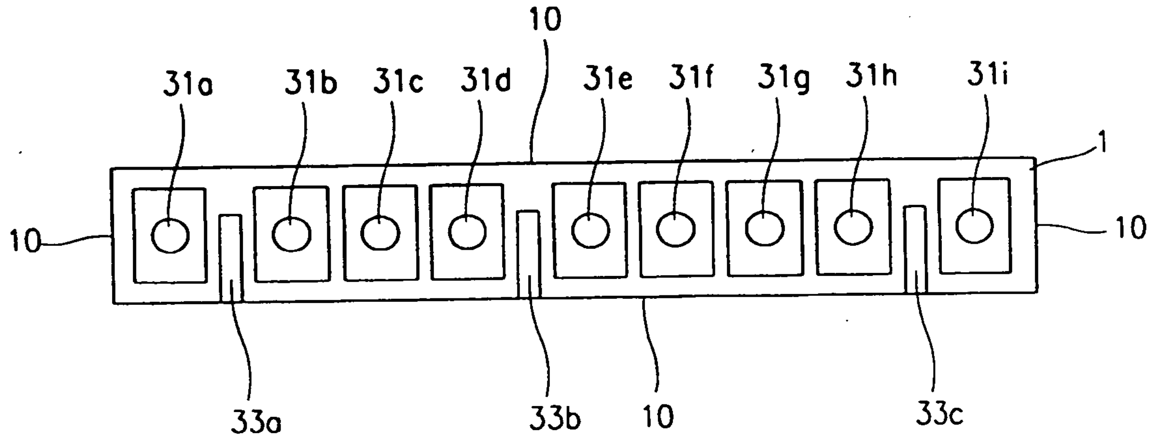

FIG. 14A

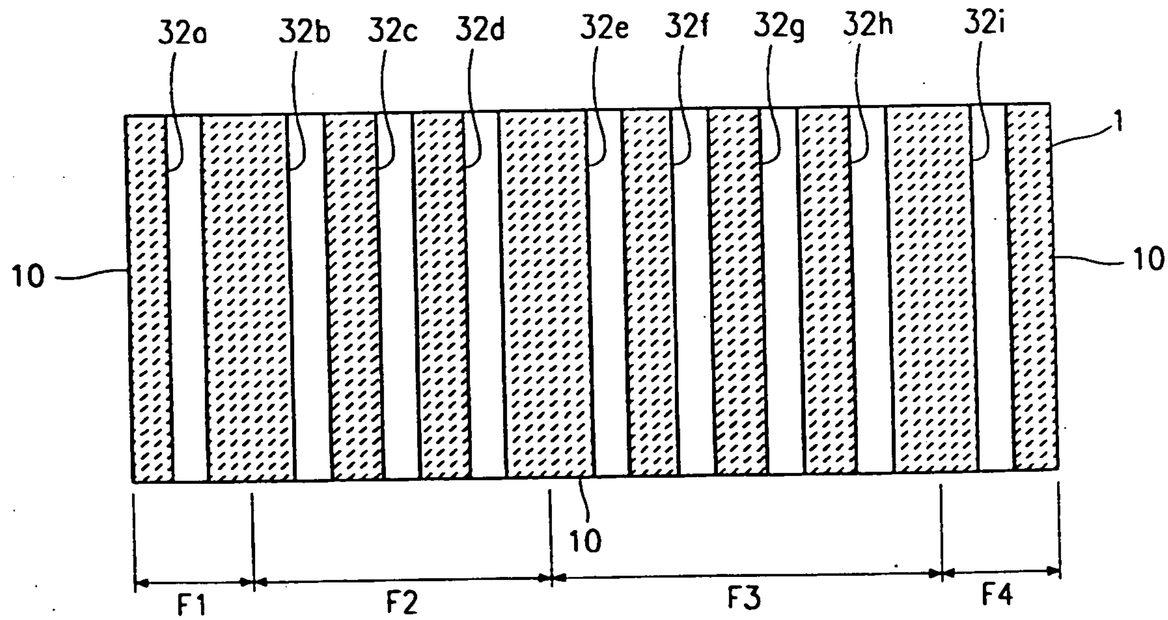

FIG. 14B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 9276

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	US 5 191 305 A (FROST ET AL.) 2 March 1993 * column 3, line 28 - column 4, line 30 * * column 10, line 11 - line 24; figure 4 *	1-3,6,7 5	H01P1/213
Y	EP 0 538 894 A (MURATA MANUFACTURING CO., LTD.) 28 April 1993 * column 16, line 44 - column 18, line 12; figure 1 *	5	
X	EP 0 654 842 A (NGK SPARK PLUG CO. LTD.) 24 May 1995 * column 3, line 37 - column 4, line 16; figure 1 *	1,3,7	
A	MATSUMOTO H ET AL: "A MINIATURIZED DIELECTRIC MONOBLOCK DUPLEXER MATCHED BY THE BURIED IMPEDANCE TRANSFORMING CIRCUIT" IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM DIGEST, ORLANDO, MAY 16 - 20, 1995, vol. 3, 16 May 1995, KIRBY L (ED), pages 1539-1542, XP000552988 * page 1539, right-hand column, line 3 - page 1540, left-hand column, line 25; figures 1,2 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01P
A	EP 0 704 924 A (MURATA MANUFACTURING CO., LTD.) 3 April 1996 * column 1, line 38 - column 2, line 7 * * column 2, line 29 - line 36 * * column 8, line 22 - line 34; figure 1 *	1,7	
A	EP 0 641 035 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD) 1 March 1995 * page 29, line 44 - line 52; figure 38 *	4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 February 1998	Den Otter, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document